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In re Application of

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For: PICTURE CODING METHOD AND PICTURE DECODING METHOD

VERIFICATION OF TRANSLATION

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

Maiko SASAKURA residing at 15-13, Kudegayacho, Nishinomiya-shi, Hyogo 662-0077 Japan declare:

(1) that she knows well both the Japanese and English languages;
(2) that she translated PICTURE CODING METHOD AND PICTURE DECODING METHOD
from Japanese to English;
(3) that the attached English translation is a true and correct translation of PICTURE CODING METHOD AND PICTURE DECODING METHOD
to the best of her knowledge and belief; and
(4) that all statements made of her own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such false statements may jeopardize the validity of the application or any patent thereon.

This 16th day of Nov., 2006

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Maiko SASAKURA

[Document] Claims

[Claims]

[Claim 1] A picture coding method for coding a picture signal by performing orthogonal transformation on the picture signal on a block-by-block basis and by quantizing frequency components obtained by the orthogonal transformation using quantization steps corresponding to frequencies, the picture coding method comprising

coding a quantization matrix in a manner that a code length becomes longer as a difference between each of the frequency components and each of predetermined frequency values K is larger, said quantization matrix being used to derive quantization steps that correspond to the frequencies of the orthogonal transformation.

[Claim 2] A picture decoding method for performing decoding by obtaining frequency components on a block-by-block basis from a coded signal that is obtained by coding a picture signal, by performing inverse quantization on the obtained frequency components using quantization steps corresponding to the respective frequency components, and by performing inverse orthogonal transformation on the inverse-quantized frequency components, the picture decoding method comprising

decoding a quantization matrix as codes whose code length becomes longer as a difference between each of the frequency components and each of predetermined frequency values K is larger, said quantization matrix being used to derive quantization steps that correspond to frequencies of the orthogonal transformation.

[Claim 3] A program for performing the picture coding method according to Claim 1 by a computer, the program causing a computer to execute the picture coding method for coding a picture signal by performing orthogonal transformation on the picture signal on a block-by-block basis and by quantizing frequency components

obtained by the orthogonal transformation using quantization steps corresponding to frequencies, the picture coding method comprising

coding a quantization matrix in a manner that a code length becomes longer as a difference between each of the frequency components and each of predetermined frequency values K is larger, said quantization matrix being used to derive quantization steps that correspond to the frequencies of the orthogonal transformation.

[Claim 4] A program for performing the picture decoding method according to Claim 2 by a computer, the program causing a computer to execute a picture decoding method for performing decoding by obtaining frequency components on a block-by-block basis from a coded signal that is obtained by coding a picture signal, by performing inverse quantization on the obtained frequency components using quantization steps corresponding to the respective frequency components, and by performing inverse orthogonal transformation on the inverse-quantized frequency components, the picture decoding method comprising

decoding a quantization matrix as codes whose code length becomes longer as a difference between each of the frequency components and each of predetermined frequency values K is larger, said quantization matrix being used to derive quantization steps that correspond to frequencies of the orthogonal transformation.

[Document] Specification

[Title of the Invention] PICTURE CODING METHOD AND PICTURE DECODING METHOD

[Technical Field]

The present invention relates to a picture coding method for efficiently compressing a moving picture and to a picture decoding method for correctly decoding it.

[Related Art]

In the age of multimedia which integrally handles audio, video and other pixel values, existing information media, i.e., newspaper, magazine, television, radio, telephone and other means through which information is conveyed to people, have recently come to be included in the scope of multimedia. Generally, multimedia refers to something that is represented by associating not only characters, but also graphics, audio, and especially pictures and the like together, but in order to include the aforementioned existing information media into the scope of multimedia, it appears as a prerequisite to represent such information in digital form.

However, when calculating the amount of information contained in each of the aforementioned information media as the amount of digital information, while the amount of information per character is 1 to 2 bytes in the case of characters, the amount of information to be required is 64Kbits per second in the case of audio (telephone quality), and 100Mbits per second in the case of moving pictures (current television reception quality). Therefore, it is not realistic for the aforementioned information media to handle such an enormous amount of information as it is in digital form. For example, although video phones are already in the actual use by using Integrated Services Digital Network (ISDN) which offers a transmission speed of 64Kbits/s to 1.5Mbits/s, it is not practical to

transmit video of televisions and cameras directly through ISDN.

Against this backdrop, information compression techniques have become required, and moving picture compression techniques compliant with H.261 and H.263 standards recommended by ITU-T (International Telecommunication Union-Telecommunication Standardization Sector) are employed for video phones, for example. Moreover, according to information compression techniques compliant with the MPEG-1 standard, it is possible to store picture information into an ordinary music CD (compact disc) together with sound information.

Here, MPEG (Moving Picture Experts Group) is an international standard on compression of moving picture signals standardized by ISO/IEC (International Organization for Standardization, International Electrotechnical Commission), and MPEG-1 is a standard for compressing television signal information approximately into one hundredth so that moving picture signals can be transmitted at a rate of 1.5Mbps. Furthermore, since a transmission speed achieved by the MPEG-1 standard is a middle-quality speed of about 1.5Mbit/s, MPEG-2, which was standardized with a view to satisfying requirements for further improved picture quality, allows data transmission equivalent in quality to television broadcasting through which moving picture signals are transmitted at a rate of 2 to 15Mbit/s. Moreover, MPEG-4 was standardized by the working group (ISO/IEC JTC1/SC29/WG11) which promoted the standardization of MPEG-1 and MPEG-2. MPEG-4, which provides a higher compression ratio than that of MPEG-1 and MPEG-2 and which enables an object-based coding/decoding/operation, is capable of providing a new functionality required in this age of multimedia. At the beginning stage of standardization, MPEG-4 aimed at providing a low bit rate coding method, but it has been extended as a standard supporting more general coding that handles interlaced images as well as high

bit rate coding. Currently, an effort has been made jointly by ISO/IEC and ITU-T for standardizing MPEG-4 AVC and ITU-T H.264 as picture coding methods of the next generation that offer a higher compression ratio. As of August 2002, a committee draft (CD) is issued for a picture coding methods of the next generation.

In general, in coding of a moving picture, the amount of information is compressed by reducing redundancies in temporal and spatial directions. Therefore, in inter picture prediction coding aiming at reducing temporal redundancies, motion estimation and the generation of a predicative image are carried out on a block-by-block basis with reference to forward or backward picture(s), and coding is then performed on the difference value between the obtained predictive image and an image in the current picture to be coded. Here, "picture" is a term denoting one image. In the case of a progressive image, "Picture" means a frame, whereas it means a frame or fields in the case of an interlaced image. Here, "interlaced image" is an image of a frame composed of two fields which are separated in capture time. In coding and decoding of an interlaced image, it is possible to handle one frame as a frame as it is, as two fields, or as a frame structure or a field structure on a per-block basis within the frame.

A picture to be coded using intra picture prediction without reference to any pictures shall be referred to as an I picture. A picture to be coded using inter picture prediction with reference to only one picture shall be referred to as a P picture. And, a picture to be coded using inter picture prediction with reference to two pictures at the same time shall be referred to as a B picture. It is possible for a B picture to refer to two pictures which can be arbitrarily combined from forward/backward pictures in display order. Reference images (reference pictures) can be determined for each block serving as a basic coding/decoding unit. Distinction shall be made between such reference pictures by calling a

reference picture to be described earlier in a coded bitstream as a first reference picture, and by calling a reference picture to be described later in the bitstream as a second reference picture. Note that as a condition for coding and decoding these types of pictures, pictures used for reference are required to be already coded and decoded.

P pictures and B pictures are coded using motion compensated inter picture prediction. Coding by use of motion compensated inter picture prediction is a coding method that employs motion compensation in inter picture prediction coding. Unlike a method for performing prediction simply based on pixel values in a reference picture, motion estimation is a technique capable of improving prediction accuracy as well as reducing the amount of data by estimating the amount of motion (hereinafter referred to as "motion vector") of each part within a picture and further by performing prediction in consideration of such amount of motion. For example, it is possible to reduce the amount of data through motion compensation by estimating motion vectors of the current picture to be coded and then by coding prediction residuals between prediction values calculated by shifting only the amount of the respective motion vectors and the current picture to be coded. In this technique, motion vectors are also recorded or transmitted in coded form, since motion vector information is required at the time of decoding.

Motion vectors are estimated on a per-macroblock basis. More specifically, a macroblock shall be previously fixed in the current picture to be coded, so as to estimate motion vectors by finding the position of the most similar reference block of such fixed macroblock within the search area in a reference picture.

FIG. 12 is a diagram illustrating an example data structure of a bitstream. As FIG. 12 shows, the bitstream has a hierarchical structure such as below. The bitstream (Stream) is formed of more

than one group of pictures (GOP). By using GOPs as basic coding units, it becomes possible to edit a moving picture as well as to make a random access. Each GOP is made up of plural pictures, each of which is one of I picture, P picture, and B picture. Each picture is further made up of plural slices. Each slice, which is a strip-shaped area within each picture, is made up of plural macroblocks. Moreover, each stream, GOP, picture, and slice includes a synchronization signal (sync) for indicating the ending point of each unit and a header (header) which is data common to said each unit.

Note that when data is carried not in a bitstream that is a sequence of streams, but in a packet and the like that is a piecemeal unit, the header and the data portion, which is the other part than the header, may be carried separately. In such case, the header and the data portion shall not be incorporated into the same bitstream, as shown in FIG. 12. In the case of a packet, however, even when the header and the data portion are not transmitted contiguously, it is simply that the header corresponding to the data portion is carried in another packet. Therefore, even when the header and the data portion are not incorporated into the same bitstream, the concept of a coded bitstream described with reference to FIG. 12 is also applicable to packets.

[Disclosure of the Invention]

[Problems that Invention is to Solve]

Generally speaking, the human sense of vision is more sensitive to the low frequency components than to the high frequency components. Furthermore, since the energy of the low frequency components in a picture signal is larger than that of the high frequency components, picture coding is performed in order from the low frequency components to the high frequency components. As a result, the number of bits required for coding the

low frequency components is larger than that required for the high frequency components.

In view of the above points, the existing coding methods use larger quantization steps for the high frequency components than for the low frequency components so as to achieve a large increase in compression ratio with a small loss of picture quality from the standpoint of viewers.

Meanwhile, since quantization step sizes of the high frequency components with regard to the low frequency components depend on picture signal, a technique for changing the sizes of quantization steps for the respective frequency components on a picture-by-picture basis has been conventionally employed. This is called a quantization matrix. FIG. 13 shows an example quantization matrix. In an example quantization matrix shown in FIG. 13, the upper left component is a DC component, whereas rightward components are horizontal high frequency components and downward components are vertical high frequency components. This quantization matrix also indicates that a larger quantization step is applied to a larger value. Usually, it is possible to use different quantization matrices for each picture. The value indicating the size of a quantization step of each frequency component is fixed length-coded. Note that it is usual that each component of a quantization matrix and the value of each quantization step are approximately proportional to each other, but it is not necessary to stick to such relationship as long as the correspondence between them is clearly defined.

However, such conventional methods have a problem that coding efficiency is lowered by simply performing fixed length coding due to the fact that the values of the respective frequency components of a quantization matrix center within a certain range.

[Means to Solve the Problems]

In order to solve the above problem,

a first invention is a picture coding method for coding a picture signal by performing orthogonal transformation on the picture signal on a block-by-block basis and by quantizing frequency components obtained by the orthogonal transformation using quantization steps corresponding to frequencies, the picture coding method comprising

coding a quantization matrix in a manner that a code length becomes longer as a difference between each of the frequency components and each of predetermined frequency values K is larger, said quantization matrix being used to derive quantization steps that correspond to the frequencies of the orthogonal transformation.

The second invention is a picture decoding method for performing decoding by obtaining frequency components on a block-by-block basis from a coded signal that is obtained by coding a picture signal, by performing inverse quantization on the obtained frequency components using quantization steps corresponding to the respective frequency components, and by performing inverse orthogonal transformation on the inverse-quantized frequency components, the picture decoding method comprising

decoding a quantization matrix as codes whose code length becomes longer as a difference between each of the frequency components and each of predetermined frequency values K is larger, said quantization matrix being used to derive quantization steps that correspond to frequencies of the orthogonal transformation.

[Effect of the Invention]

As described above, by variable length-coding a quantization matrix, it becomes possible to improve coding ratio that in the case of a conventional fixed length coding. Thus, the present invention is highly practical.

[Embodiments of the Present Invention]

Referring to FIGs. 1 to 11, the embodiments of the present invention are described.

(First Embodiment)

FIG. 1 shows an example of variable length coding according to the present invention.

FIG. 1(a), which illustrates a first example, shows a relationship between code words (code) and values of the respective components (value) of the quantization matrix. Here, difference values can take positive values, and therefore the larger the values, the less frequently they occur. Thus, the smaller the values, the shorter the length of their code words to be assigned. Conversion from the value of each component into a code word can be easily carried out using an arithmetic expression shown in FIG. 1(a).

FIG. 1(b), which illustrates a second example, is applicable to the case where the value of each component of a quantization matrix is most likely to take a predetermined value K. Since the occurrence frequency of the predetermined value K is high, the code length becomes shortest when the value of a frequency component is K, with the code length becoming longer as the value of a frequency component is distant from K.

FIG. 2 shows an order of coding a quantization matrix according to the present invention. Orthogonal transformation in picture coding is most frequently performed for each 4×4 pixels or for each 8×8 pixels. In view of this, FIGs. 2(a) and 2(b) illustrate an example of 4×4 pixels and FIGs. 2(c) and 2(d) illustrate an example of 8×8 pixels. In the present embodiment, since each frequency component in a quantization matrix is coded on an individual basis by use of a code word shown in FIG. 1, there is no difference in coding efficiency regardless of whether coding is performed from lower frequency components to higher frequency components as shown in FIGs. 2(a) and 2(c) or simply in horizontal

order as shown in FIGs. 2(b) and 2(d).

(Second Embodiment)

FIG. 3 shows an example of variable length coding according to the present invention. When each component of a quantization matrix is coded in order shown in FIG. 2, the values of neighboring frequency components are strongly correlated. Thus, by coding the value of a component as a difference value between the previously coded component value and such component when performing coding in order shown in FIG. 2, the resulting difference values center around 0. Thus, it becomes possible to further reduce the number of bits required for coding a quantization matrix by assigning code words with shorter code length to values around 0 and assigning code words with longer code length to values distant from 0, as FIG. 3 shows.

(Third Embodiment)

FIG. 4 shows a data structure of a quantization matrix according to the present invention. In this drawing, Header is equivalent to the header of a stream/GOP/picture shown in FIG. 12. FIG. 4(a) shows the values of a quantization matrix, wherein Wi,j denotes a component of the quantization matrix in the j-th row in the i-th line. FIGs. 4(b) and 4(c) illustrate how each data obtained by coding each component of the quantization matrix is arranged in the header. WeightingMatrix represents a bitstream obtained by coding the quantization matrix. FIG. 4(b) shows a stream obtained by performing coding in order shown in FIG. 2(c), whereas FIG. 4(c) shows a stream obtained by performing coding in order shown in FIG. 2(d). Note that Wi, j in the streams shown in FIGs. 4(b) and 4(c) indicates that this is a coded stream corresponding to Wi, j.

(Fourth Embodiment)

FIG. 5 is a block diagram showing the construction of a picture coding apparatus according to the present invention.

A moving picture coding apparatus 1, which is an apparatus

for performing compression coding on an input picture signal Vin and outputting a coded picture signal Str which has been coded into a bitstream by performing variable length coding and the like, is comprised of a motion estimation unit ME, a motion compensation unit MC, a subtraction unit Sub, an orthogonal transformation unit T, a quantization unit Q, an inverse quantization unit IQ, an inverse orthogonal transformation unit IT, an addition unit Add, a picture memory PicMem, a switch SW, and a variable length coding unit VLC.

The picture signal Vin is inputted to the subtraction unit Sub and the motion estimation unit ME. The subtraction unit Sub calculates differences between the input picture signal Vin and predictive images, and outputs the calculated differences to the orthogonal transformation unit T. The orthogonal transformation unit T performs orthogonal transformation on each difference to transform it into frequency coefficients, and outputs them to the quantization unit Q. The quantization unit Q quantizes the input frequency coefficients, using quantization steps that are derived by reference to a quantization matrix WM inputted from outside, and outputs the resulting quantized values Qcoef to the variable length coding unit.

The inverse quantization unit IQ performs inverse quantization on the quantized values Qcoef using quantization steps that are derived by reference to the quantization matrix WM, so as to turn them into the frequency coefficients, and outputs them to the inverse orthogonal transformation unit IT. The inverse orthogonal transformation unit IT performs inverse frequency transformation on the frequency coefficients so as to transform them into a pixel difference, and outputs it to the addition unit Add. The addition unit Add adds each pixel difference and each predictive image outputted from the motion estimation unit MC, so as to form a decoded image. The switch SW turns ON when it is indicated that such decoded image should be stored, and such decoded image is to

be stored into the picture memory PicMem.

Meanwhile, the motion estimation unit ME, which receives the picture signal Vin on a macroblock basis, detects an image area closest to such input image signal Vin from among decoded pictures stored in the picture memory PicMem, and determines motion vector(s) MV indicating the position of such area. Motion vectors are estimated for each block, which is obtained by further dividing a macroblock. When this is done, since a plurality of pictures can be used as reference pictures, identification numbers (reference index Index) to identify the respective reference pictures are required on a block-by-block basis. The association between a reference index and the picture number of each picture stored in the picture memory PicMem makes it possible for a reference picture to be designated.

The motion compensation unit MC reads out an optimum image area as a predictive picture from among the decoded pictures stored in the picture memory PicMem, based on the motion vectors detected in the above processing and on the reference indices Index.

The variable length coding unit VLC performs variable length coding on each of the quantization matrices WM, quantized values Qcoef, reference indices Index, and motion vectors MV so as to output them as a coded stream Str.

(Fifth Embodiment)

FIG. 6 is a block diagram showing a picture decoding apparatus according to the present invention. In this drawing, units that operate in the same manner as that of the units in the picture coding apparatus shown in FIG. 5 are assigned the same numbers, and descriptions thereof are omitted.

The variable length decoding unit VLD decodes the coded stream Str and outputs the quantization matrices WM, quantized values Qcoef, reference indices Index, and motion vectors MV. Decoding is performed on each of the quantization matrices QM,

quantized values Qcoef, reference indices Index, and motion vectors MV through the picture memory PicMem, the motion compensation unit MC, and the inverse quantization unit IQ. This operation is already described above with reference to the block diagram of the picture coding apparatus according to the present invention shown in FIG. 5.

(Sixth Embodiment)

Furthermore, if a program for realizing the picture coding method and the picture decoding method as shown in the aforementioned embodiments are recorded on a recording medium such as a flexible disk, it becomes possible to easily perform the processing presented in the above embodiments in an independent computer system.

FIG. 7 is a diagram illustrating the case where the picture coding method and picture decoding method according to the aforementioned embodiments are executed as a program stored in a recording medium such as flexible disk in a computer system.

FIG. 7(b) shows an external view of a flexible disk viewed from the front, its schematic cross-sectional view, and the flexible disk itself, while FIG. 7(a) illustrates an example physical format of the flexible disk as a recording medium itself. The flexible disk FD is contained in a case F, and a plurality of tracks Tr are formed concentrically on the surface of the flexible disk FD in the radius direction from the periphery, each track being divided into 16 sectors Se in the angular direction. Therefore, in the flexible disk storing the above-mentioned program, the picture coding method and the picture decoding method as such program is recorded in an area allocated for it on the flexible disk FD.

Meanwhile, FIG. 7(c) shows the structure required for recording and reading out the program on and from the flexible disk FD. When the program realizing the above picture coding method and picture decoding method is to be recorded onto the flexible disk

FD, such program shall be written by the use of the computer system Cs via a flexible disk drive. Meanwhile, when the picture coding method and the picture decoding method are to be constructed in the computer system through the program on the flexible disk, the program shall be read out from the flexible disk via the flexible disk drive and then transferred to the computer system.

The above description is given on the assumption that a recording medium is a flexible disk, but an optical disc may also be used. In addition, the recording medium is not limited to this, and any other medium such as an IC card and a ROM cassette capable of recording a program can also be used.

(Seventh Embodiment)

The following describes application examples of the picture coding method and picture decoding method as shown in the above embodiments as well as a system using them.

FIG. 8 is a block diagram showing an overall configuration of a content supply system ex100 that realizes a content distribution service. The area for providing a communication service is divided into cells of desired size, and base stations ex107~ex110, which are fixed wireless stations, are placed in the respective cells.

In this content supply system ex100, devices such as a computer ex111, a PDA (Personal Digital Assistant) ex112, a camera ex113, a cellular phone ex114, and a camera-equipped cellular phone ex115 are respectively connected to the Internet ex101 via an Internet service provider ex102, a telephone network ex104, and the base stations ex107~ex110.

However, the content supply system ex100 is not limited to the combination as shown in FIG. 8, and may be connected to a combination of any of them. Also, each of the devices may be connected directly to the telephone network ex104, not via the base stations ex107~ex110, which are fixed wireless stations.

The camera ex113 is a device such as a digital video camera

capable of shooting moving pictures. The cellular phone may be a cellular phone of a PDC (Personal Digital Communication) system, a CDMA (Code Division Multiple Access) system, a W-CDMA (Wideband-Code Division Multiple Access) system or a GSM (Global System for Mobile Communications) system, a PHS (Personal Handyphone system) or the like, and may be any one of these.

Furthermore, a streaming server ex103 is connected to the camera ex113 via the base station ex109 and the telephone network ex104, which enables live distribution or the like based on coded data transmitted by the user using the camera ex113. Either the camera ex113 or a server and the like capable of data transmission processing may code the shot data. Also, moving picture data shot by a camera ex116 may be transmitted to the streaming server ex103 via the computer ex111. The camera ex116 is a device such as a digital camera capable of shooting still pictures and moving pictures. In this case, either the camera ex116 or the computer ex111 may code the moving picture data. In this case, an LSI ex117 included in the computer ex111 or the camera ex116 performs coding processing. Note that software for coding and decoding may be integrated into a certain type of storage medium (such as a CD-ROM, a flexible disk and a hard disk) that is a recording medium readable by the computer ex111 and the like. Furthermore, the camera-equipped cellular phone ex115 may transmit the moving picture data. This moving picture data is data coded by an LSI included in the cellular phone ex115.

In this content supply system ex100, content (e.g., a music live video) which has been shot by the user using the camera ex113, the camera ex116 or the like is coded in the same manner as the above-described embodiments and transmitted to the streaming server ex103, and the streaming server ex103 makes stream distribution of the content data to clients at their request. The clients here include the computer ex111, the PDA ex112, the camera

ex113, the cellular phone ex114 and so forth capable of decoding the above coded data. The content supply system ex100 with the above configuration is a system that enables the clients to receive and reproduce the coded data and realizes personal broadcasting by allowing them to receive, decode and reproduce the data in real time.

The picture coding apparatus and picture decoding apparatus presented in the above embodiments can be used for coding and decoding to be performed in each of the devices making up the above system.

An explanation is given of a cellular phone as an example.

FIG. 9 is a diagram showing the cellular phone ex115 that employs the picture coding method and the picture decoding method explained in the above embodiments. The cellular phone ex115 has an antenna ex201 for transmitting/receiving radio waves to and from the base station ex110, a camera unit ex203 such as a CCD camera capable of shooting video and still pictures, a display unit ex202 such as a liquid crystal display for displaying the data obtained by decoding video and the like shot by the camera unit ex203 and video and the like received by the antenna ex201, a main body equipped with a group of operation keys ex204, a voice output unit ex208 such as a speaker for outputting voices, a voice input unit ex205 such as a microphone for inputting voices, a recording medium ex207 for storing coded data or decoded data such as data of moving pictures or still pictures shot by the camera, data of received e-mails and moving picture data or still picture data, and a slot unit ex206 for enabling the recording medium ex207 to be attached to the cellular phone ex115. The recording medium ex207 is embodied as a flash memory element, a kind of EEPROM (Electrically Erasable and Programmable Read Only Memory) that is an electrically erasable and rewritable nonvolatile memory, stored in a plastic case such as an SD card.

Next, referring to FIG. 10, a description is given of the cellular phone ex115. In the cellular phone ex115, a main control unit ex311 for centrally controlling the display unit ex202 and each unit of the main body having the operation keys ex204 is configured in a manner in which a power supply circuit unit ex310, an operation input control unit ex304, a picture coding unit ex312, a camera interface unit ex303, an LCD (Liquid Crystal Display) control unit ex302, a picture decoding unit ex309, a multiplexing/demultiplexing unit ex308, a recording/reproducing unit ex307, a modem circuit unit ex306, and a voice processing unit ex305 are interconnected via a synchronous bus ex313.

When a call-end key or a power key is turned on by a user operation, the power supply circuit unit ex310 supplies each unit with power from a battery pack, and activates the camera-equipped digital cellular phone ex115 to make it into a ready state.

In the cellular phone ex115, the voice processing unit ex305 converts a voice signal received by the voice input unit ex205 in conversation mode into digital voice data under the control of the main control unit ex311 comprised of a CPU, a ROM, a RAM and others, the modem circuit unit ex306 performs spread spectrum processing on it, and a transmit/receive circuit unit ex301 performs digital-to-analog conversion processing and frequency transformation processing on the data, so as to transmit the resultant via the antenna ex201. Also, in the cellular phone ex115, data received by the antenna ex201 in conversation mode is amplified and performed of frequency transformation processing and analog-to-digital conversion processing, the modem circuit unit ex306 performs inverse spread spectrum processing on the resultant, and the voice processing unit ex305 converts it into analog voice data, so as to output it via the voice output unit ex208.

Furthermore, when sending an e-mail in data communication mode, text data of the e-mail inputted by operating the operation

keys ex204 on the main body is sent out to the main control unit ex311 via the operation input control unit ex304. In the main control unit ex311, after the modem circuit unit ex306 performs spread spectrum processing on the text data and the transmit/receive circuit unit ex301 performs digital-to-analog conversion processing and frequency transformation processing on it, the resultant is transmitted to the base station ex110 via the antenna ex201.

When picture data is transmitted in data communication mode, the picture data shot by the camera unit ex203 is supplied to the picture coding unit ex312 via the camera interface unit ex303. When picture data is not to be transmitted, it is also possible to display such picture data shot by the camera unit ex203 directly on the display unit ex202 via the camera interface unit ex303 and the LCD control unit ex302.

The picture coding unit ex312, which includes the picture coding apparatus according to the present invention, performs compression coding on the picture data supplied from the camera unit ex203 using the coding method employed by the picture coding apparatus presented in the above embodiments, so as to convert it into coded picture data, and sends it out to the multiplexing/demultiplexing unit ex308. At this time, the cellular phone ex115 sends voices received by the voice input unit ex205 while the shooting by the camera unit ex203 is taking place, to the multiplexing/demultiplexing unit ex308 as digital voice data via the voice processing unit ex305.

The multiplexing/demultiplexing unit ex308 multiplexes the coded picture data supplied from the picture coding unit ex312 and the voice data supplied from the voice processing unit ex305 using a predetermined method, the modem circuit unit ex306 performs spread spectrum processing on the resulting multiplexed data, and the transmit/receive circuit unit ex301 performs digital-to-analog

conversion processing and frequency transformation processing on the resultant, so as to transmit the processed data via the antenna ex201.

When receiving, in data communication mode, moving picture file data which is linked to a Web page or the like, the modem circuit unit ex306 performs inverse spread spectrum processing on the received signal received from the base station ex110 via the antenna ex201, and sends out the resulting multiplexed data to the multiplexing/demultiplexing unit ex308.

In order to decode the multiplexed data received via the antenna ex201, the multiplexing/demultiplexing unit ex308 separates the multiplexed data into a coded bitstream of picture data and a coded bitstream of voice data, and supplies such coded picture data to the picture decoding unit ex309 and such voice data to the voice processing unit ex305 via the synchronous bus ex313.

Next, the picture decoding unit ex309, which includes the picture decoding apparatus according to the present invention, decodes the coded bitstream of the picture data using the decoding method paired with the coding method shown in the above-mentioned embodimenst so as to generate moving picture data for reproduction, and supplies such data to the display unit ex202 via the LCD control unit ex302. Accordingly, moving picture data included in the moving picture file linked to a Web page, for instance, is displayed. At the same time, the voice processing unit ex305 converts the voice data into an analog voice signal, and then supplies this to the voice output unit ex208. Accordingly, voice data included in the moving picture file linked to a Web page, for instance, is reproduced.

Note that the aforementioned system is not an exclusive example and therefore that at least either the picture coding apparatus or the picture decoding apparatus of the above embodiments can be incorporated into a digital broadcasting system

as shown in FIG. 11, against the backdrop that satellite/terrestrial digital broadcasting has been a recent topic of conversation. To be more specific, at a broadcasting station ex409, a coded bitstream of video information is transmitted, by radio waves, to a satellite ex410 for communications or broadcasting. Upon receipt of it, the broadcast satellite ex410 transmits radio waves for broadcasting, an antenna ex406 of a house equipped with satellite broadcasting reception facilities receives such radio waves, and an apparatus such as a television (receiver) ex401 and a set top box (STP) ex407 decodes the coded bitstream and reproduces the decoded data. The picture decoding apparatus as shown in the above-mentioned embodiment can be implemented in the reproduction apparatus ex403 for reading and decoding the coded bitstream recorded on a storage medium ex402 that is a recording medium such as a CD and a DVD. In this case, a reproduced video signal is displayed on a monitor ex404. It is also conceivable that the picture decoding apparatus is implemented in the set top box ex407 connected to a cable ex405 for cable television or the antenna ex406 for satellite/terrestrial broadcasting so as to reproduce it on a television monitor ex408. In this case, the picture decoding apparatus may be incorporated into the television, not in the set top box. Or, a car ex412 with an antenna ex411 can receive a signal from the satellite ex410, the base station ex107 or the like, so as to reproduce a moving picture on a display device such as a car navigation system ex413 mounted on the car ex412.

Furthermore, it is also possible to code a picture signal by the picture coding apparatus presented in the above embodiment and to record the resultant in a recording medium. Examples include a DVD recorder for recording a picture signal on a DVD disc ex421 and a recorder ex420 such as a disc recorder for recording a picture signal on a hard disk. Moreover, a picture signal can also be recorded in an SD card ex422. If the recorder ex420 is equipped

with the picture decoding apparatus presented in the above embodiment, it is possible to reproduce a picture signal recorded on the DVD disc ex421 or in the SD card ex422, and display it on the monitor ex408.

As the configuration of the car navigation system ex413, the configuration without the camera unit ex203 and the camera interface unit ex303, out of the configuration shown in FIG. 10, is conceivable. The same is applicable to the computer ex111, the television (receiver) ex401 and the like.

Concerning the terminals such as the cellular phone ex114, a transmitting/receiving terminal having both an encoder and a decoder, as well as a transmitting terminal only with an encoder, and a receiving terminal only with a decoder are possible as forms of implementation.

As stated above, it is possible to employ the picture coding method and the picture decoding method presented in the above embodiments into any one of the above-described devices and systems. Accordingly, it becomes possible to achieve an effect described in the aforementioned embodiments.

[Industrial Applicability]

[Brief Description of Drawings]

FIG. 1 is a diagram showing an example of variable length coding according to the present invention (First Embodiment).

FIG. 2 is a diagram showing an order of coding a quantization matrix according to the present invention (First Embodiment).

FIG. 3 is a diagram showing an example of variable length coding according to the present invention (Second Embodiment).

FIG. 4 is a diagram showing a data structure of a quantization matrix according to the present invention (Third Embodiment).

FIG. 5 is a block diagram showing the picture coding apparatus according to the present invention (Fourth Embodiment).

FIG. 6 is a block diagram showing the picture decoding

apparatus according to the present invention (Fifth Embodiment).

FIG. 7 is a diagram illustrating a recording medium that stores a program for executing the picture coding method and picture decoding method according to the aforementioned embodiments in a computer system (Sixth Embodiment),

FIG. 8 is a block diagram showing an overall configuration of the content supply system (Seventh Embodiment).

FIG. 9 is a diagram showing an example cellular phone that employs the picture coding method and picture decoding method (Seventh Embodiment).

FIG. 10 is a block diagram showing the cellular phone (Seventh Embodiment).

FIG. 11 is a diagram showing an example of the digital broadcasting system (Seventh Embodiment).

FIG. 12 is a diagram illustrating an example data structure of a bitstream.

FIG. 13 is a diagram showing an example quantization matrix.

The following is a memo

Coded stream Str

Variable length coding unit VLC

Variable length decoding unit VLD

FIG. 1

(a)

code	value
1	1
010	2
011	3
00100	4
00101	5
00110	6
00111	7

$\underbrace{000\cdots001}_{N\text{ zeros}}X_0\,X_1\,X_2\cdots X_{N-1}$

$Value=2^N+X_0\,X_1\,X_2\cdots X_{N-1}$

(b)

code	value
1	K
010	K+1
011	K-1
00100	K+2
00101	K-2
00110	K+3
00111	K-3

$\underbrace{000\cdots001}_{N\text{ zeros}}X_0\,X_1\,X_2\cdots X_{N-1}$

```
if (N==0)
  value = K
else
  value = K+(-1)^(X_{N-1}) ·
  (2^(N-1)+X_0 X_1 X_2 ··· X_{N-2})
```

FIG. 2

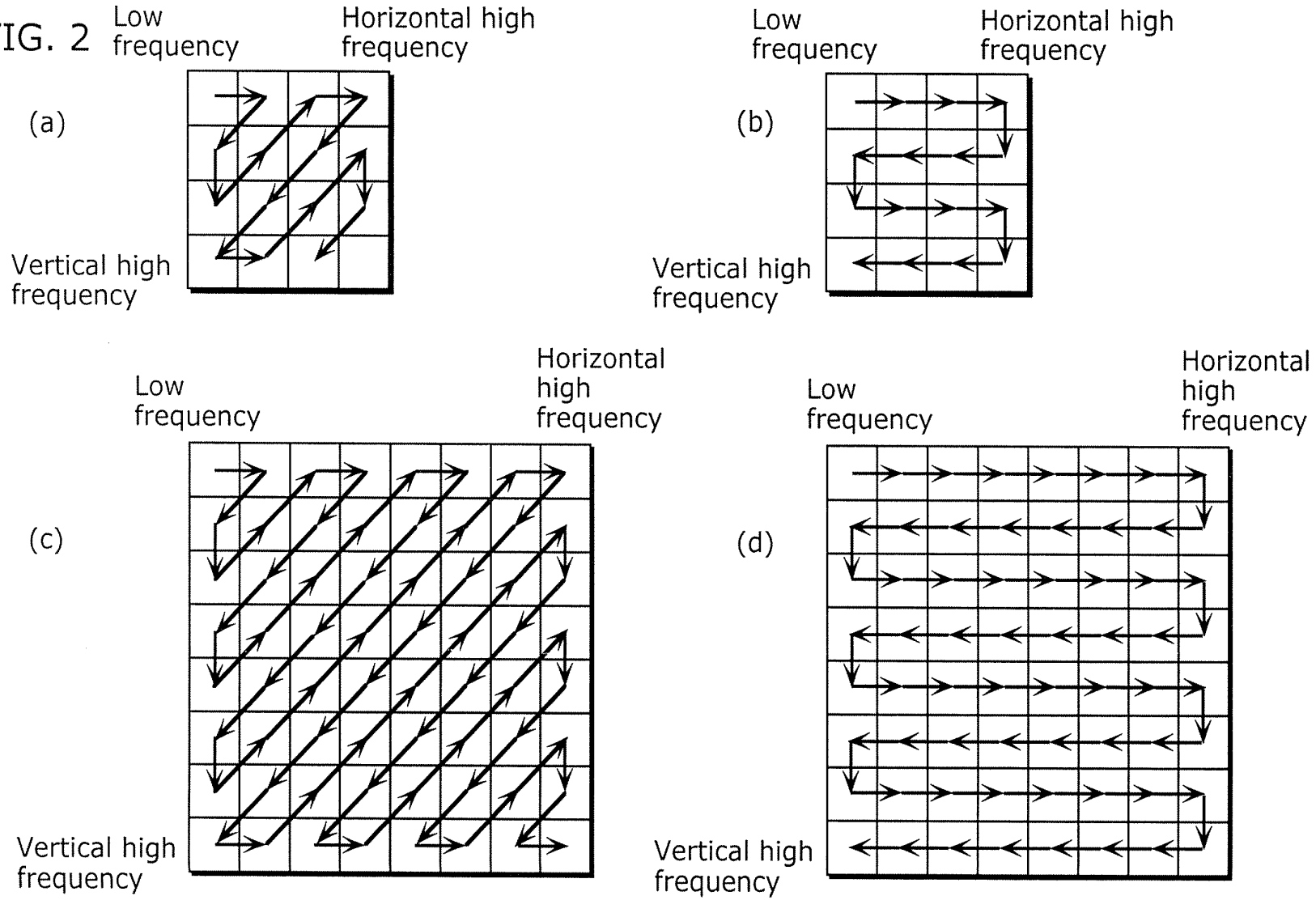

Low frequency
Horizontal high frequency
(a)
Vertical high frequency
Low frequency
Horizontal high frequency
(b)
Vertical high frequency
Low frequency
Horizontal high frequency
(c)
Vertical high frequency
Low frequency
Horizontal high frequency
(d)
Vertical high frequency

FIG. 3

code	value
1	0
010	1
011	-1
00100	2
00101	-2
00110	3
00111	-3

$$\underbrace{000\cdots001}_{\text{N zeros}}\ X_0\ X_1\ X_2\cdots X_{N-1}$$

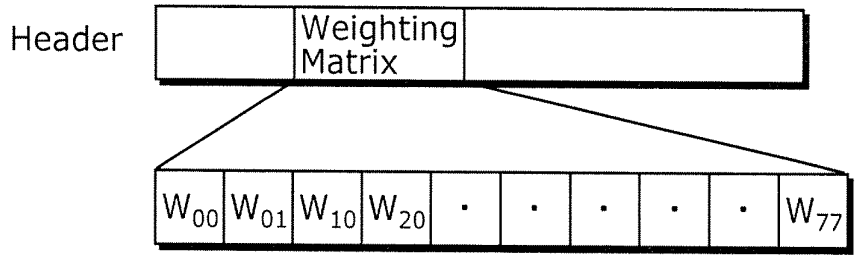
```
if (N==0)
  value = 0
else
  value = (-1)^(X_{N-1}) ·(2^(N-1)+X_0 X_1 X_2··· X_{N-2})
```

FIG. 4

(a)

W_{00}	W_{01}	W_{02}	W_{03}	W_{04}	W_{05}	W_{06}	W_{07}
W_{10}	W_{11}	W_{12}	W_{13}	W_{14}	W_{15}	W_{16}	W_{17}
W_{20}	W_{21}	W_{22}	W_{23}	W_{24}	W_{25}	W_{26}	W_{27}
W_{30}	W_{31}	W_{32}	W_{33}	W_{34}	W_{35}	W_{36}	W_{37}
W_{40}	W_{41}	W_{42}	W_{43}	W_{44}	W_{45}	W_{46}	W_{47}
W_{50}	W_{51}	W_{52}	W_{53}	W_{54}	W_{55}	W_{56}	W_{57}
W_{60}	W_{61}	W_{62}	W_{63}	W_{64}	W_{65}	W_{66}	W_{67}
W_{70}	W_{71}	W_{72}	W_{73}	W_{74}	W_{75}	W_{76}	W_{77}

(b)



(c)

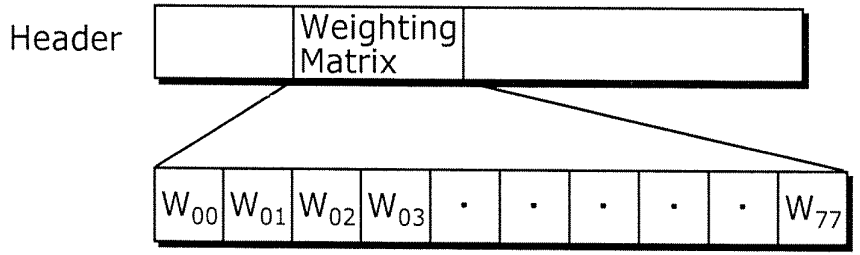


FIG. 5

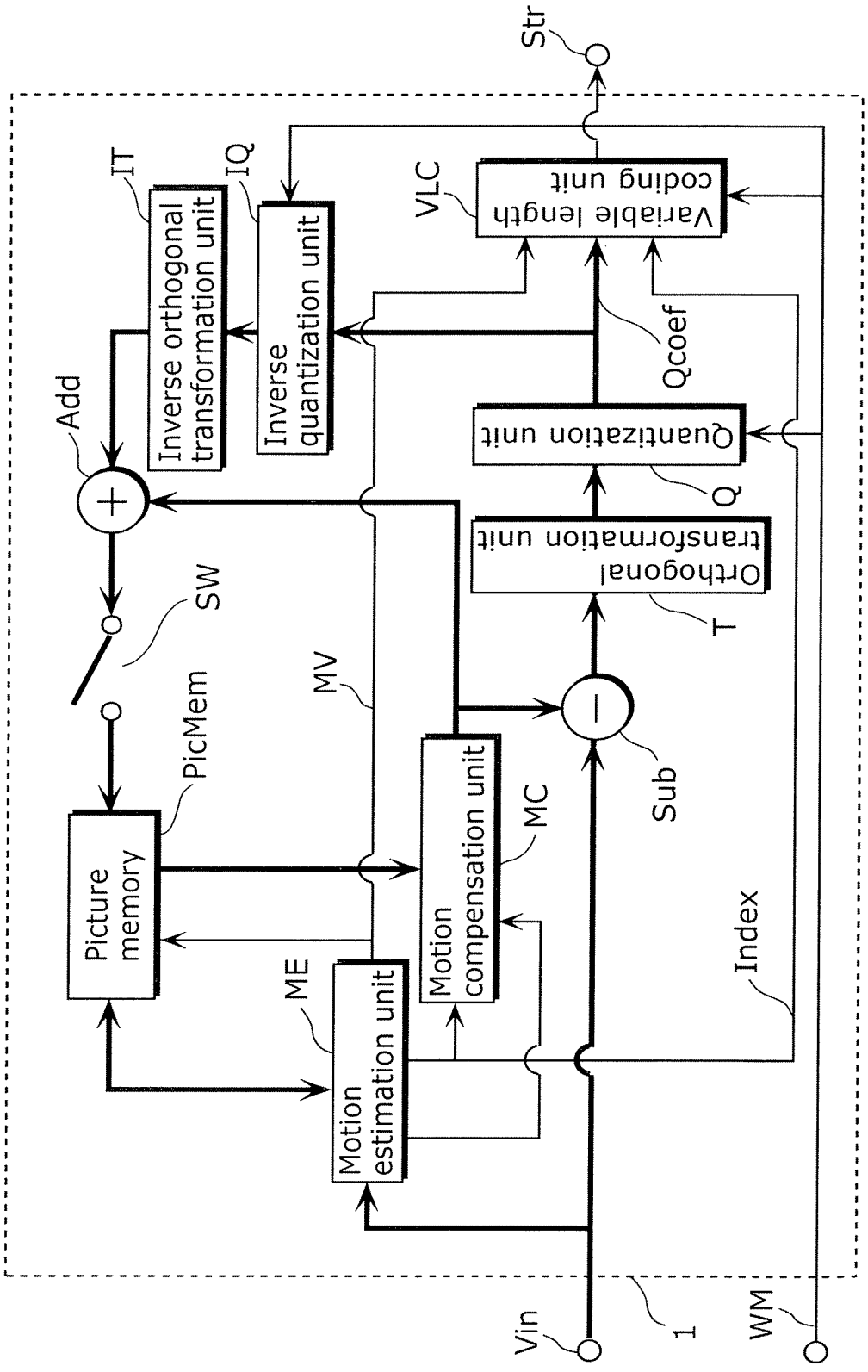

Str
IT
IQ
VLC
Inverse orthogonal transformation unit
Inverse quantization unit
Variable length coding unit
Add
Qcoef
Quantization unit
Q
Orthogonal transformation unit
T
SW
MV
PicMem
Sub
Picture memory
Motion compensation unit
MC
ME
Motion estimation unit
Index
Vin
1
WM

FIG. 6

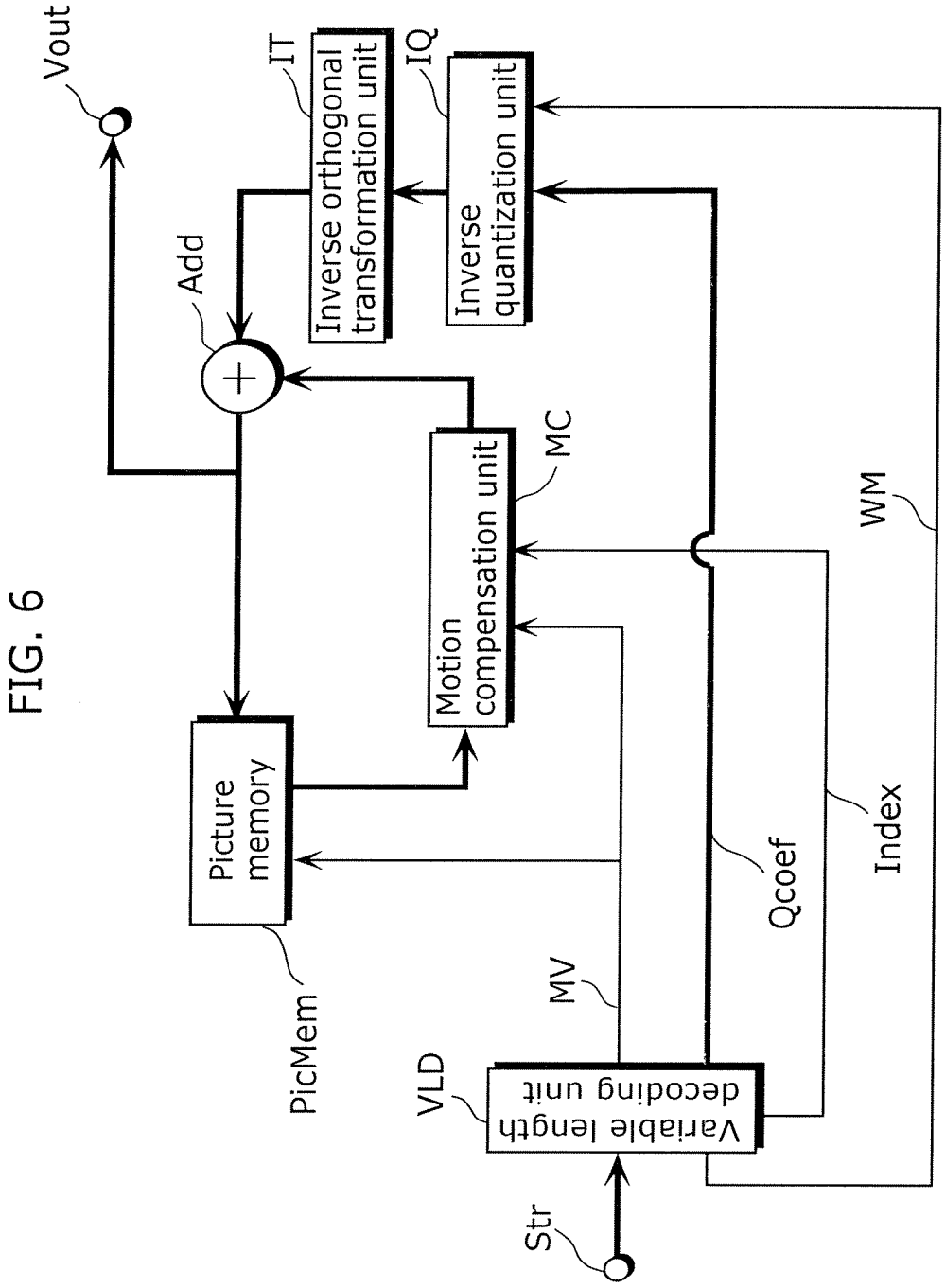

Vout
IT
Inverse orthogonal transformation unit
IQ
Inverse quantization unit
Add
Motion compensation unit
MC
WM
Picture memory
PicMem
MV
VLD
Variable length decoding unit
Qcoef
Index
Str

FIG. 7

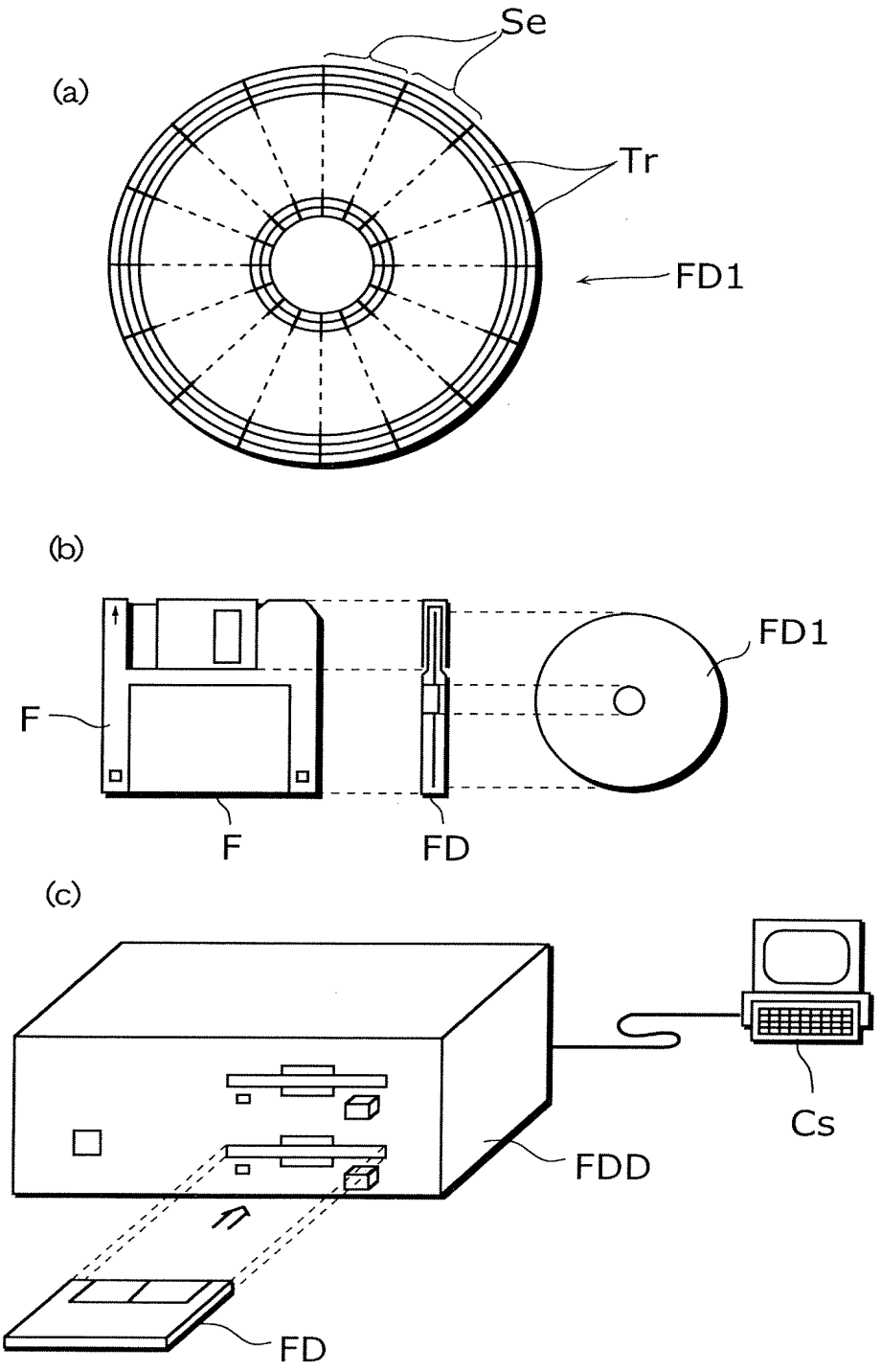


FIG. 8

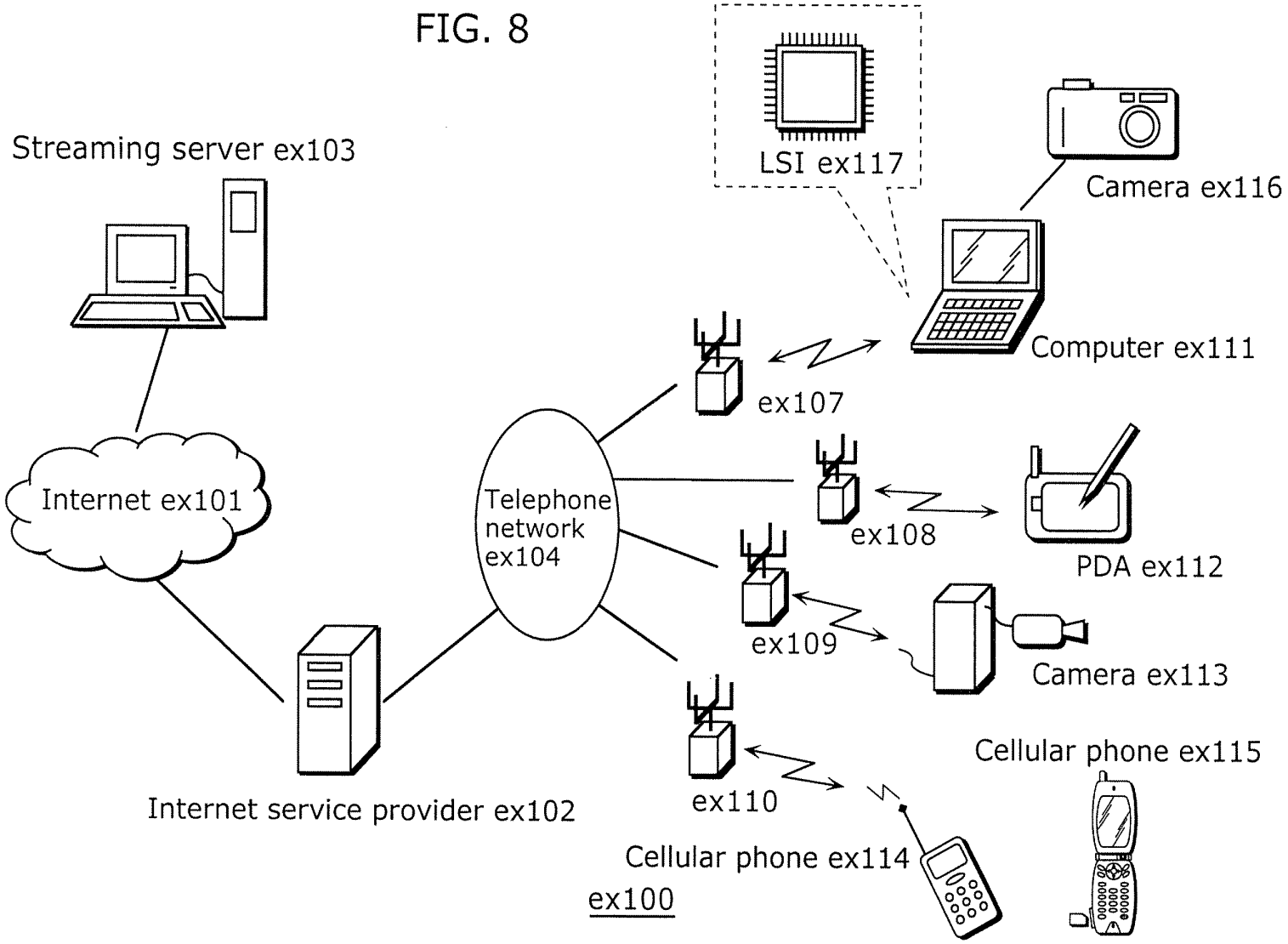

Streaming server ex103
LSI ex117
Camera ex116
Computer ex111
ex107
Internet ex101
Telephone network ex104
ex108
PDA ex112
ex109
Camera ex113
Cellular phone ex115
Internet service provider ex102
ex110
Cellular phone ex114
ex100

FIG. 9

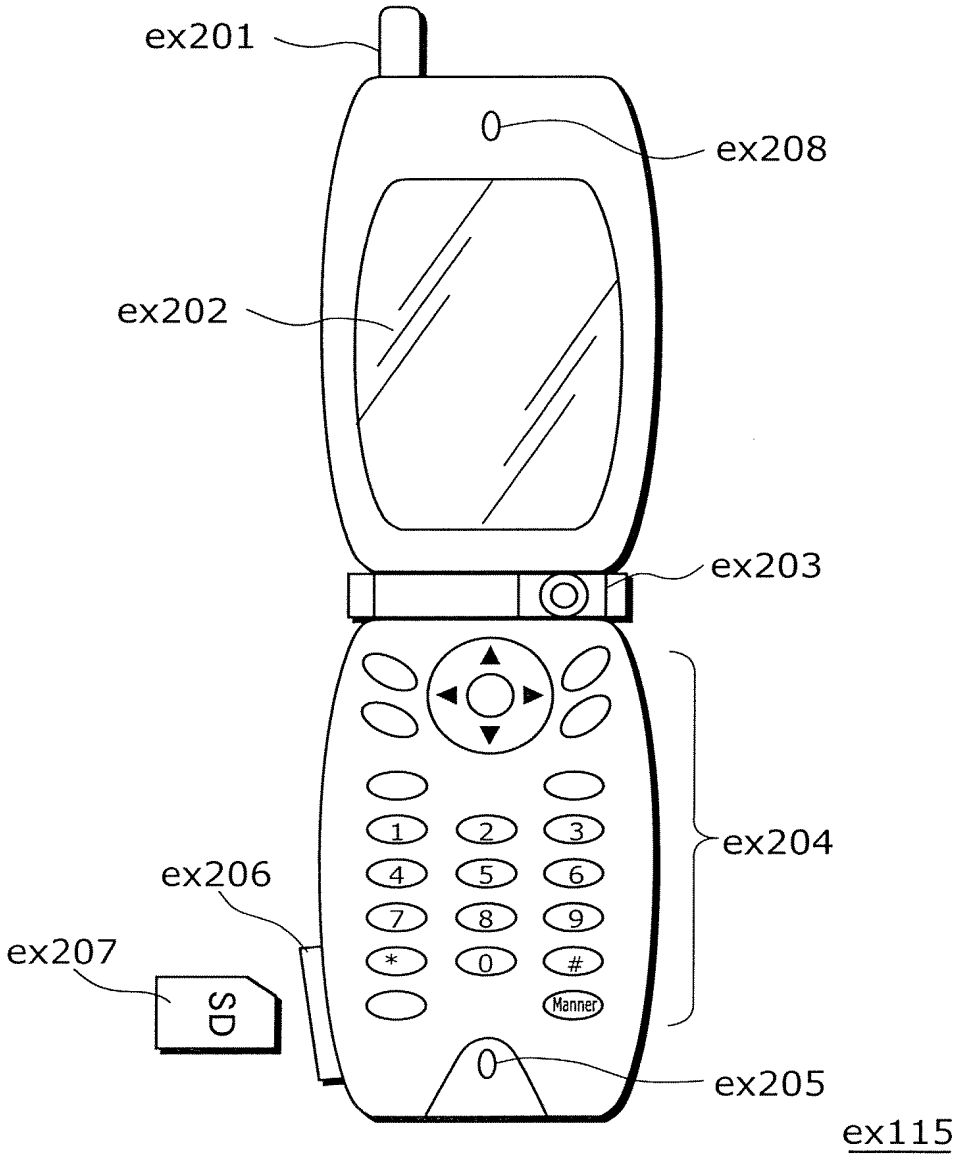

ex201
ex208
ex202
ex203
ex204
ex206
ex207
SD
ex205
ex115
1
2
3
4
5
6
7
8
9
*
0
#
Manner

FIG. 10

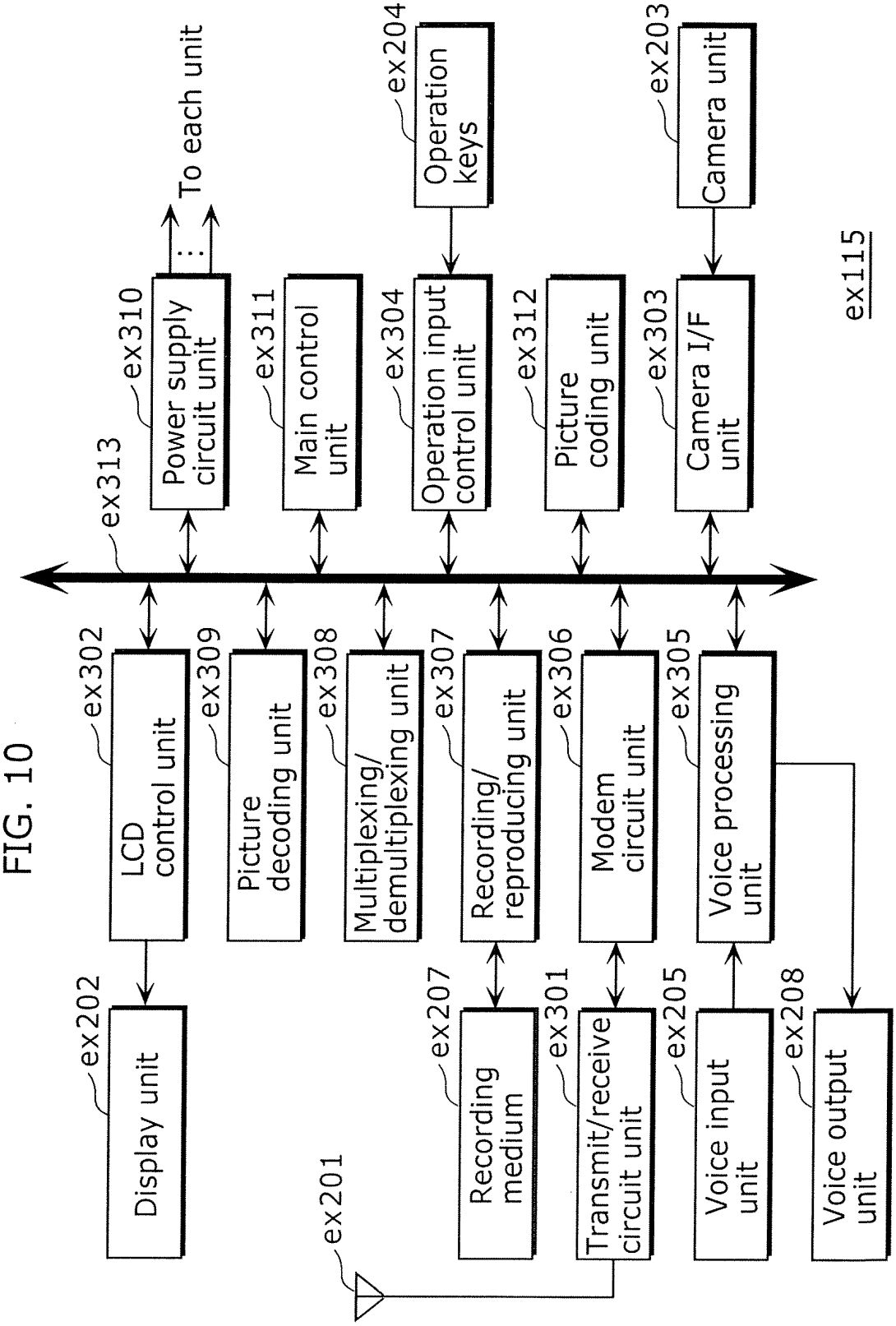

ex115
ex313
ex310
Power supply circuit unit
To each unit
ex311
Main control unit
ex304
Operation input control unit
ex204
Operation keys
ex312
Picture coding unit
ex303
Camera I/F unit
ex203
Camera unit
ex302
LCD control unit
ex309
Picture decoding unit
ex308
Multiplexing/ demultiplexing unit
ex307
Recording/ reproducing unit
ex306
Modem circuit unit
ex305
Voice processing unit
ex202
Display unit
ex207
Recording medium
ex301
Transmit/receive circuit unit
ex205
Voice input unit
ex208
Voice output unit
ex201

FIG. 11

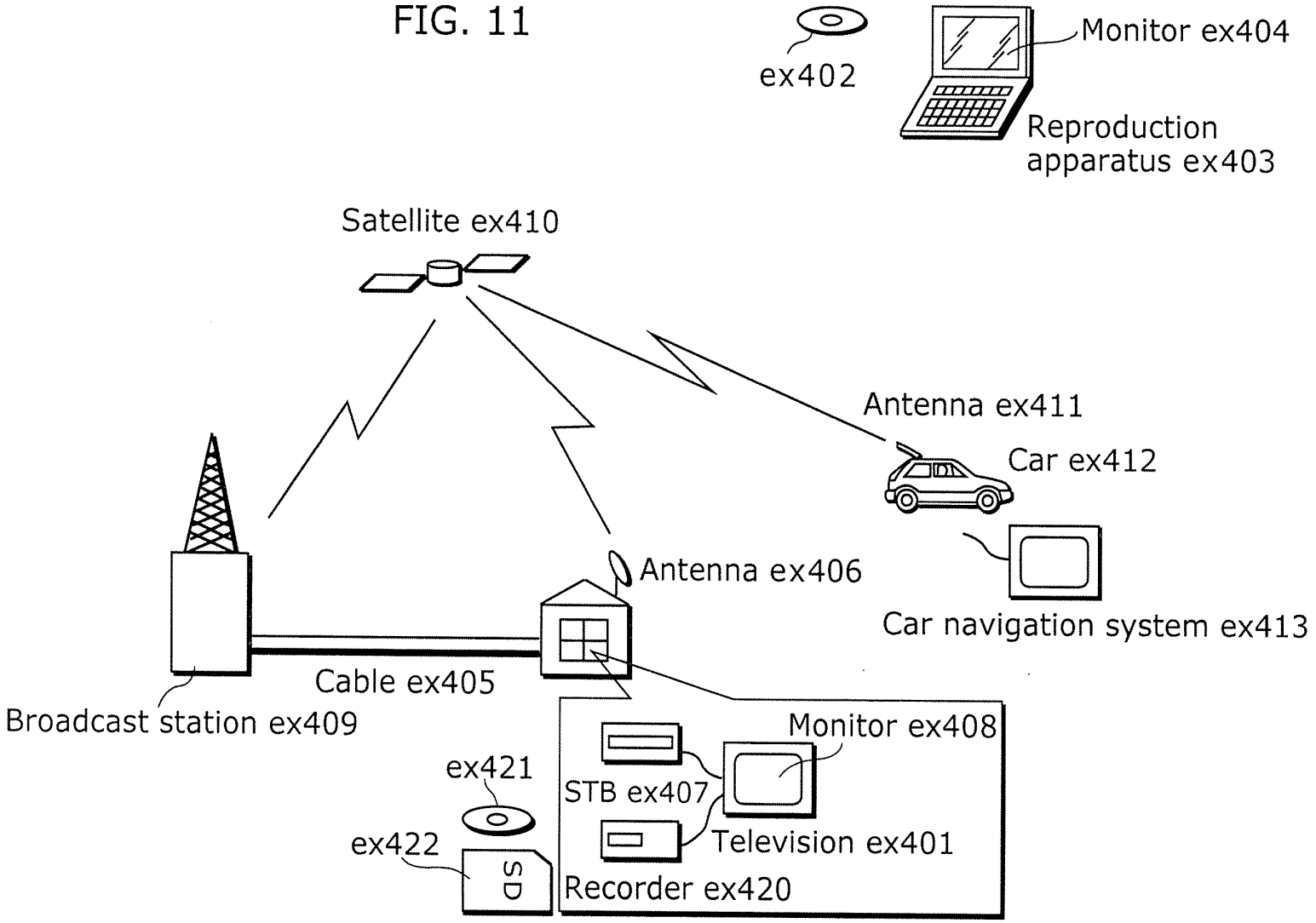

ex402
Monitor ex404
Reproduction apparatus ex403
Satellite ex410
Antenna ex411
Car ex412
Antenna ex406
Car navigation system ex413
Cable ex405
Broadcast station ex409
Monitor ex408
ex421
STB ex407
ex422
Television ex401
SD
Recorder ex420

FIG. 12

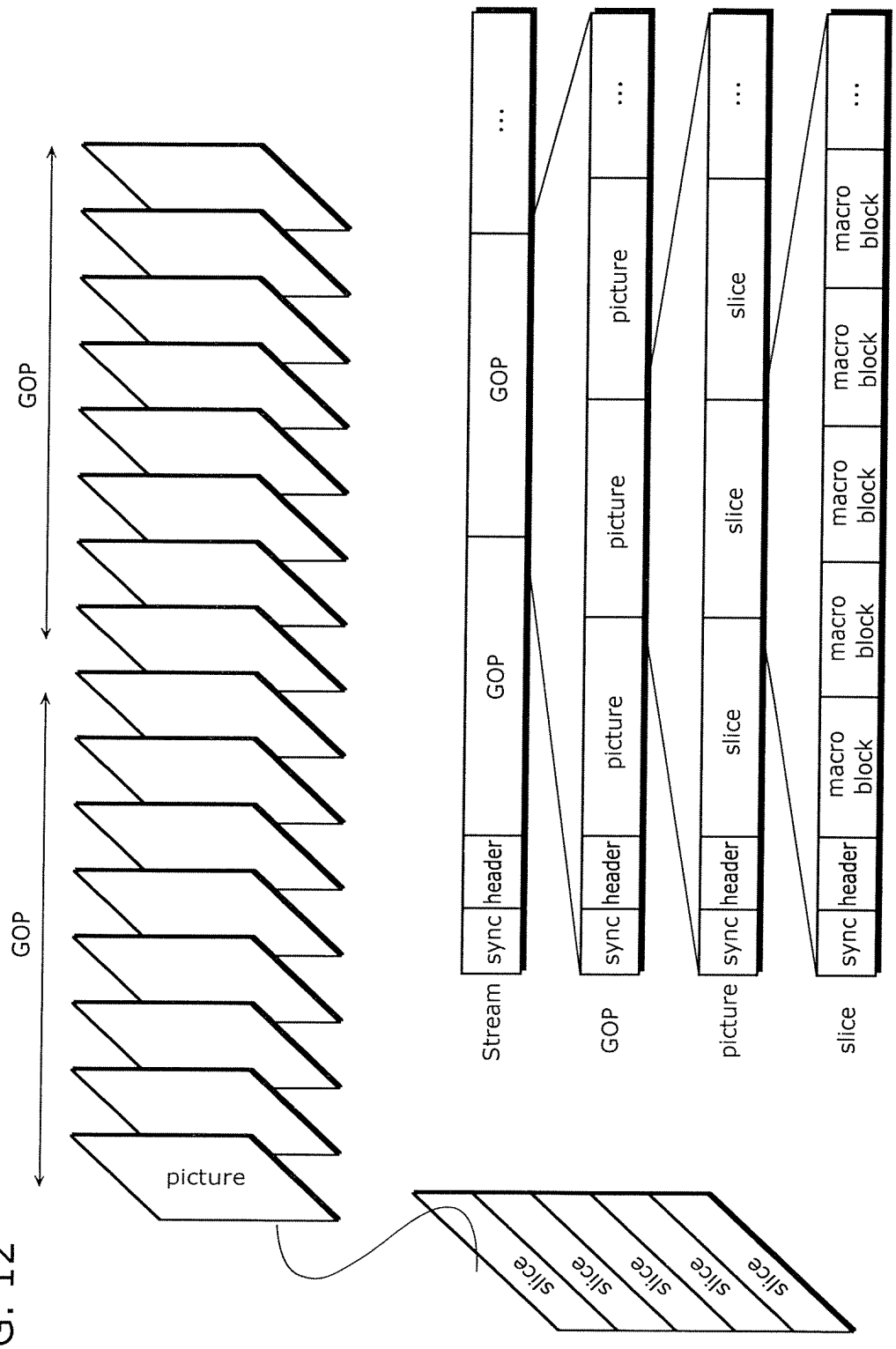

GOP
GOP
picture
slice
slice
slice
slice
slice
Stream
sync
header
GOP
...
GOP
sync
header
picture
picture
...
picture
sync
header
slice
slice
...
slice
sync
header
macro block
macro block
macro block
macro block
...

FIG. 13

Low frequency

Horizontal high frequency

8	16	19	22	26	27	29	34
16	16	22	24	27	29	34	37
19	22	26	27	29	34	34	38
22	22	24	27	29	34	37	40
22	26	27	29	32	35	40	48
26	27	29	32	35	40	48	58
26	27	29	34	38	46	56	69
27	29	35	38	46	56	69	83

Vertical high frequency